MONITORING PLAN FOR ENERGY STAR SHOWCASE BUILDINGS PROGRAM

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I. PURPOSE

The purpose of Showcase Building monitoring is to document energy savings and support downsizing decisions using a credible and consistent approach. The results of this monitoring will be used in marketing materials. This monitoring plan developed through the Showcase Buildings program will become the suggested monitoring plan to be used by all Energy Star Building Partners.

II. PHASES

All points listed below will be monitored in the following three Phases;

Phase I: Monitoring prior to beginning any upgrade procedures;

Phase II: Monitoring after upgrades are completed for the first 3 Stages (Green Lights; Building Tune-Up; Load Reductions); and

Phase III: Monitoring after upgrades are completed for the final Stages (HVAC Distribution systems, HVAC Plant).

III. PROCEDURE

This building monitoring plan will be a combination of 1) ongoing measurements, and 2) one time measurements taken before and after each Phase of the Showcase Buildings project. Measurements will be obtained from the energy management system (EMS). If the building does not have a properly functioning EMS, stand-alone meters, data loggers, or manual readings will be used to collect needed data points. Selected measurements will be recorded every 30 minutes during a **14 day testing period**. The 30 minute monitoring interval must be identical for each point monitored. Peak load conditions will be monitored to determine the correct downsizing of the HVAC equipment.

Prior to performing any measurements, all testing procedures should be carefully reviewed and all the necessary equipment procured. **Optimal** testing methods are listed in the METHODS section. If the optimal test method cannot be used, a **Desired** alternate method is provided. For some points, an alternate **Minimal** method has also been included. ***Any exceptions or deviations to this monitoring procedure must be documented.***

Selected floor(s) for monitoring will represent the typical heating/cooling load of the building. Monitored points include: lighting levels; associated lighting panels; plug loads; air handling units (AHUs), chilled water, hot water, and condenser water systems; and any other equipment serving the selected area.

All meters and sensors used in the monitoring must be accurately calibrated. Amprobes used should be of the true RMS (root mean square) type. If there is any doubt, verify the accuracy of any sensor, meter, or gauge with a similar calibrated device.

All attempts should be made to use accurate kW meters for the once electric measurements. However, if kW meters are not available, then calibrated amprobes of the true RMS may be used, supplemented by manufacturer's ratings of power factor at the estimated percent load observed.

IV. POINTS LIST

The following points will be monitored either continuously (every 30 minutes) for the duration of the program, or periodically before/after various Phases. The monitoring frequency, duration, and procedure are explained in the METHODS section. Points are listed in subsequent sections by their identity (e.g. A1, A2, B1 etc.). ***Any exceptions or deviations to this monitoring procedure must be documented.***

A. Outside Air Conditions

A1. Outside Air Temperature (°F)
A2. Outside Air Relative Humidity (% RH)

B. Lighting

B1. Lighting Electric Load(kW)
B2. Lighting Level (FC)

C. Office Equipment

C1. Office Equipment Electric Load (kW)

D. Air Distribution

D1. Fan Electric Load (kW)
D2. Fan Output (cfm)
D3. Duct Static Pressure Setpoint (in. w.c.)
D4. Supply Air Temp. (°F)
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E. Cooling

E1. Chiller Electric Load (kW)
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E. Cooling (cont'd.)

E5. Chilled Water Flowrate (gpm)
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E7. Chilled Water Supply Temperature (°F)
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F1. Boiler Electric Load (kW)
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F3. Hot Water Flowrate (gpm)
F4. Hot Water Supply Temperature (°F)
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F6. Electric Reheat Load (kW)
F7. Steam Flowrate (lbs/hr)
F8. Steam Pressure (psig)
F9. Gas/Oil Flowrate (cfh)

G. Others

This is for the remaining load that will be calculated from the total building load minus items A-F.

V. METHODS

A1. OUTSIDE AIR TEMPERATURE (OAT)

Device: Dry bulb temperature sensor.

Duration: Total length of project.

Frequency: Every 30 minutes (averaged).

Purpose: To calculate the load. The building cooling and heating loads at various ambient temperatures are then determined and used to project the annual energy use.

Method: Optimal- In almost all cases, OAT is monitored through the EMS.

Desired- Data may be obtained from the National Weather Service.

A2. OUTSIDE AIR HUMIDITY (OARH)

Device: Relative humidity sensor.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To calculate the load and the effectiveness of cooling towers and evaporative coolers.

Method: Optimal- In almost all cases, OARH is monitored through the EMS.

Desired- Use a sling psychrometer and take a measurement at 2 pm and compare this to National Weather Service, if possible.

Minimal- Data may be obtained from local weather service centers.

B1a. LIGHTING ELECTRICAL LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the electric energy consumption of the lighting system in the building, and subsequently the energy savings due to Phase II upgrades.

Method:

Optimal- Connect a kW meter to the selected building lighting panel. Monitor continuously through the EMS or data logger.

Desired- Connect a kW meter to the selected building lighting panel. Use a data logger or strip recorder and monitor for 24 hours on both a typical weekday and weekend during Phase I and after Phase II. Take measurements every 30 minutes.

Minimal- Connect a kW meter to the selected building lighting panel. Take one measurement during a typical day (2 pm) during Phase I and after Phase II.

B1b. LIGHTING RUN-TIME

Device: Lighting logger.

Duration: Phase I and after Phase II.

Frequency: Once.

Purpose: To determine the feasibility and energy savings of using occupancy sensors.

Method:

Optimal- Connect a lighting logger to one fixture for each typical space use.

Desired- Perform a statistical count throughout the building, noting the percentage of areas that are unoccupied and with the lights turned off.

B2. LIGHTING LEVEL

Device: Light meter.

Duration: Phase I and after Phase II (after lamps have gone through a 100-hour burn-in period).

Frequency: Once.

Purpose: To measure the lighting level in Phase I, determine the required change and confirm the lighting level compliance with the Green Lights recommendations after Phase II upgrades.

Method: Select several zones which are a good representative of the building (2-3 samples per space use). Place the light meter on the workplane (table, desk) and take a reading, then take readings throughout the space using a 9-point grid layout. Caution should be taken as to not allow anything in between the work plane and all lighting sources in the space other than the person sitting on the chair at the usual location. If the lights have been off, wait a few minutes after turning them on before taking the reading.

C1. OFFICE EQUIPMENT ELECTRICAL LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the plug load energy consumption before and after the Energy Star Computers upgrade.

Method:

Optimal- Connect a kW meter to the selected building plug load panel. Monitor continuously through the EMS or data logger.

Desired- Connect a kW meter to the selected building plug load panel. Use a data logger or strip recorder and monitor for 24 hours on both a typical weekday and weekend during Phase I and after Phase II. Take measurements every 30 minutes.

Minimal- Connect a kW meter to the selected building plug load panel. Take one measurement during a typical day (2 pm) during Phase I and after Phase II.

D1a. VAV FAN ELECTRIC LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes

Purpose: To determine the variable air volume (VAV) fan energy consumption and the VAV fan energy savings due to the various upgrades.

Method: Optimal- Connect a kW meter to the selected AHU's motor. Monitor continuously through the EMS or data logger.

Desired- Connect a kW meter to the selected AHU's motor. Use a data logger or strip recorder and monitor for 24 hours on both a typical weekday and weekend during Phase I and after Phases II and III. Take measurements every 30 minutes.

D1b. CAV FAN ELECTRIC LOAD

Device: kW meter.

Duration: Phase I and after Phases II and III.

Frequency: Once.

Purpose: To determine the constant air volume (CAV) fan energy consumption and the fan energy savings due to installing a VAV system.

Method: Connect a kW meter to the selected AHU's motor. Take a measurement on a typical day (2 pm).

D2a. VAV FAN OUTPUT

Device: Airflow monitoring station (AFMS) or velocity and static pressure transmitters.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose:
1) To determine the amount of air needed to cool/heat the building, which will also reflect the cooling/heating load.
2) To be used in conjunction with point D1 (Fan Electric Load) to determine the fan electric load and savings at various Phases.
3) To determine peak load in conjunction with point D1.

Method:
1) Monitor through EMS or data logger.
2) Operate the fan at increments of 10% from 100% down to the fan's minimum cfm and record the motor electric load at each increment to determine the fan load profile.
3) During a peak day determine the peak airflow needed for the area served by the subject AHU by recording airflow and electric load measurements every 30 minutes.

D2b. CAV FAN OUTPUT

Device: Velocity pressure transmitter or a pitot tube with a magnehelic gauge.

Duration: Phase I and after Phase III.

Frequency: Once.

Purpose: To determine the amount of air needed to cool/heat the building, which will also reflect the cooling/heating load.

Method: Take a measurement on a typical day (2 pm).

D3a. VAV DUCT STATIC PRESSURE

Device: Static pressure sensor.

Duration: Total length of project .

Frequency: Every 30 minutes.

Purpose: To determine the electric energy savings due to lowering the static pressure setpoint. The static pressure setpoint may be too high from the start and during the Tune-up (Stage 2), this setpoint may be lowered. The static pressure setpoint may be lowered further after Phase II due to lower airflow requirements.

Method: Optimal- Monitor through EMS or data logger.

Desired- On a typical day, measure with a data logger for 24 hours during Phase I and after Phase II.

Minimal- Take a measurement on a typical day (2 pm) during Phase I and after Phase II.

D3b. CAV DUCT STATIC PRESSURE

Device: Static pressure sensor.

Duration: Phase I and after Phase II.

Frequency: Once.

Purpose: To determine the electric energy savings due to lowering the static pressure setpoint. The static pressure setpoint may be too high from the start and during the Tune-up (Stage 2), this setpoint may be lowered. The static pressure setpoint may be lowered further after Phase II due to lower airflow requirements.

Method: Take a measurement on a typical day (2 pm).

D4&D5a. SUPPLY AND RETURN AIR TEMPERATURES
Variable Temperature Systems

Device: Temperature sensors.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the cooling/heating load of the building.

Method: Monitor through EMS or data logger.

D4&D5b. SUPPLY AND RETURN AIR TEMPERATURES
Constant Temperature Systems

Device: Temperature sensors.

Duration: Phase I and after Phase II.

Frequency: Once.

Purpose: To determine the cooling/heating load of the building.

Method: Take a manual measurement with a duct temperature probe.

D6. MIXED AIR TEMPERATURE

Device: Temperature sensor.

Duration: Total length of project.

Frequency: Every 30 minutes, coincident with the supply and return air temperature readings.

Purpose: To determine the outside air quantity intake to the building. This is used to ensure adequate fresh air supply and to calculate the cooling/heating load.

Method: Monitored through the EMS or data logger.

NOTE: In all cases, care should be taken to ensure an accurate reading. In some cases, the sensor location is not adequate, and the sensor needs to be moved to an area where the return and outside air have completely mixed, typically right before the filter. If the sensor is not recording an accurate average temperature, then several sensors may be placed strategically in the duct work in order to obtain an average temperature. Also, a piece of conduit (of duct length) with several holes drilled into it can be used with a sensor to obtain an average temperature reading.

E1. CHILLER ELECTRIC LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the peak chiller load.

Method: Without manipulating any parameters of the chiller or its accessories, monitor the chiller kW through the EMS or data logger. *Note: assure that outside air conditions, and chilled and condenser water conditions are monitored at the same time.*

E2a. COOLING TOWER FAN WITH VSD ELECTRIC LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the energy savings from the cooling tower fans due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Monitor through EMS or data logger.

E2b. COOLING TOWER FAN ELECTRIC LOAD

Device: kW meter.

Duration: Phase I and after Phase III.

Frequency: Once.

Purpose: To determine the energy savings from the cooling tower fans due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Take a measurement during a typical day (2 pm).

E3&E4a. CHILLED WATER AND CONDENSER WATER PUMPS ELECTRIC LOADS Variable Flow

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the pump electric energy savings due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Monitor through EMS or data logger.

E3&E4b. CHILLED WATER AND CONDENSER WATER PUMPS ELECTRIC LOADS Constant Flow

Device: kW meter.

Duration: Phase I and after Phase III.

Frequency: Once.

Purpose: To determine the pump electric energy savings due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Take a measurement during a typical day (2 pm).

E5&E6a. CHILLED WATER AND CONDENSER WATER FLOWRATES
Variable Flow

Device: Flowmeter or pressure gauge.

Duration: Total length of project

Frequency: Every 30 minutes.

Purpose: To determine the cooling load and the pump energy savings due to various upgrades and installation of VSD on pumps.

Method: Optimal- Monitor with a flowmeter through the EMS or data logger.

Desired- Monitor with a differential pressure gauge through a data logger. The differential pressure gauge may be installed in place of the existing inlet and outlet pressure gauges. The pressure difference between the pump inlet and outlet, when used in conjunction with the pump curves, determines the water flow through the pump.

E5&E6b. CHILLED WATER AND CONDENSER WATER FLOWRATES
Constant Flow

Device: Flowmeter or pressure gauge.

Duration: Phase I and after Phase II.

Frequency: Once.

Purpose: To determine the cooling load and the pump energy savings due to various upgrades and installation of VSD on pumps.

Method: Take a measurement with a flowmeter or differential pressure gauge during a typical day (2 pm). The differential pressure gauge may be installed in place of the existing inlet and outlet pressure gauges. The pressure difference between the pump inlet and outlet, when used in conjunction with the pump curves, determines the water flow through the pump. In the absence of a differential pressure gauge, a test quality calibrated pressure gauge may be used. Replace each of the existing pressure gauges at the pump inlet and outlet in turn with the calibrated gauge and record the pressures. The flowrate may be obtained by subtracting the inlet pressure from the outlet pressure and then using the pump curve. In the absence of the pump curve or suitable pressure gauge location, the same readings may be taken at the inlet and outlet of the chiller tube bundles. However, the tubes must have been recently cleaned. The chiller pressure drop/flowrate curves will then be used to determine the flowrates.

E7,E8,E9&E10. CHILLED WATER SUPPLY AND RETURN TEMPERATURES, CONDENSER WATER SUPPLY AND RETURN TEMPERATURES

Device: Temperature sensors.

Duration: Total length of the project.

Frequency: Every 30 minutes.

Purpose: To determine the building cooling load, the energy savings due to various upgrades, and to develop the cooling load profile.

Method: Monitor through EMS or data logger.

F1. BOILER ELECTRIC LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the heating load and to develop the heating load profile of the building.

Method: Measure the electric load with a kW meter at the MCC. Monitor through the EMS or data logger.

F2a. HEATING WATER PUMP ELECTRIC LOAD
Variable Flow

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the pump electric energy savings due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Monitor through EMS or data logger.

F2b. HEATING WATER PUMP ELECTRIC LOAD
Constant Flow

Device: kW meter.

Duration: Phase I and after Phase III.

Frequency: Once.

Purpose: To determine the pump electric energy savings due to various upgrades.

Method: Measure the motor electric load with a kW meter at the MCC. Take a measurement on a typical day (9 am).

F3a. HOT WATER FLOWRATE
Variable Flow

Device: Flowmeter or pressure gauge.

Duration: Total length of project

Frequency: Every 30 minutes.

Purpose: To determine the heating load and the pump energy savings due to various upgrades and installation of VSD on pumps.

Method: Optimal- Monitor with a flowmeter through the EMS or data logger.

Desired- Monitor with a differential pressure gauge through a data logger. The differential pressure gauge may be installed in place of the existing inlet and outlet pressure gauges. The pressure difference between the pump inlet and outlet, when used in conjunction with the pump curves, determines the water flow through the pump.

F3b. HOT WATER FLOWRATE
Constant Flow

Device: Flowmeter or pressure gauge.

Duration: Phase I and after Phase III.

Frequency: Once.

Purpose: To determine the heating load and the pump energy savings due to various upgrades and installation of VSD on pumps.

Method: Take a measurement with a flowmeter or differential pressure gauge. The differential pressure gauge may be installed in place of the existing inlet and outlet pressure gauges. The pressure difference between the pump inlet and outlet, when used in conjunction with the pump curves, determines the water flow through the pump. In the absence of a differential pressure gauge, a test quality calibrated pressure gauge may be used. Replace each of the existing pressure gauges at the pump inlet and outlet in turn with the calibrated gauge and record the pressures. The flowrate may be obtained by subtracting the inlet pressure from the outlet pressure and then using the pump curve. In the absence of the pump curve or suitable pressure gauge location, the same readings may be taken at the inlet and outlet of the boiler. The boiler pressure drop/flowrate curves will then be used to determine the flowrates.

F4&F5. HOT WATER SUPPLY AND RETURN TEMPERATURES

Devices: Temperature sensors.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the building heating load, the energy requirements at each phase, and to develop the heating load profile of the building.

Method: Monitor through the EMS or data logger.

F6a. ELECTRIC REHEAT LOAD

Device: kW meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the reheat load requirements at various phases, and to calculate the effect of GL & ESC on the reheat load of the building.

Method: If all reheat coils in the building are on the same circuit, add that circuit to the EMS (provided it does not have any other variable loads). As another option, a stand-alone meter/logger may be installed at the panel serving the reheat coils. If the reheat coils are on more than one circuit, find one panel which feeds a large external zone (or a floor) of the building, and add to the EMS or install a stand-alone meter for that area. Again, no other variable loads should be on the selected circuit. If the circuit has some constant loads on it in addition to the electric reheat coils, those loads need to be measured and subtracted from the total circuit load.

F6b. REHEAT LOAD

Device: Temperature sensor.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: To determine the reheat load requirements at various phases, and to calculate the effect of GL & ESC on the reheat load of the building.

Method: Monitor the temperature after the reheat coil through the EMS or data logger.

F7. STEAM FLOWRATE

Device: Steam meter, BTU meter, or condensate meter.

Duration: Total length of project.

Frequency: Every 30 minutes.

Purpose: In buildings heated by steam purchased from outside sources, the purpose of this monitoring is to determine the heating load of the building and the efficiency of the heat exchanger.

Method: Optimal- Install a steam or BTU meter to the main heating steam supply in the building and monitor through the EMS or data logger. *Note: this is not necessarily the main steam supply line into the building since steam may be used for purposes other than heating.*

Desired- A condensate meter may be used. *Note: assure that the traps and fittings do not leak.*

F8. STEAM PRESSURE

Device: Pressure gauge.

Duration: Phase I and after Phase II.

Frequency: Once.

Purpose: Used in conjunction with the steam flowrate (in pounds per hour) to calculate the heating load in BTU.

Method: In almost all cases, a pressure gauge is installed on the low pressure steam line downstream of the pressure reducing valve (PRV) station. Replace the existing gauge with a calibrated pressure gauge and take a measurement.

F9. FUEL FLOWRATE

Device: Fuel flowmeter.

Durations: Total length of project.

Frequency: Every 30 minutes.

Purpose: In buildings which have fossil fuel boilers, this monitoring is needed in order to determine the heating load, and boiler efficiency.

Method: Monitor through the EMS or data logger.

G. OTHERS

The purpose of this is to determine the other building loads, including elevators, domestic hot water and pumps, and other miscellaneous equipment. These loads represent the difference between the total building loads and those which are monitored (items A through F).

VI. MONITORING INSTRUMENTATION

Point(s) Identity	Device		
	Sensor	Measurement	Location
A1	Temperature	EMS	O.A. Intake
A2	Relative Humidity	EMS	O.A. Intake
B1	kW Meter	EMS	Electric Panel
B2	Light Meter	Manual	Sample Rooms
C1	kW Meter	EMS	Electric Panel
D1	kW Meter	EMS	MCC
D2	AFMS/Velocity, Static Pressure	EMS	Main S.A. Duct
D3	Static Pressure	EMS	Main S.A. Duct
D4	Temperature	EMS	Main S.A. Duct
D5	Temperature	EMS	Main R.A. Duct
D6	Temperature	EMS	Mixed Air Plenum
E1	kW Meter	EMS	MCC
E2	kW Meter	EMS	MCC
E3	kW Meter	EMS	MCC
E4	kW Meter	EMS	MCC
E5	Flowmeter	EMS	Main Chilled Water Pipe
E6	Flowmeter	EMS	Main Condenser Water Pipe
E7	Temperature	EMS	Chilled Water Supply Pipe

E8	Temperature	EMS	Chilled Water Return Pipe
E9	Temperature	EMS	Condenser Wtr. Supply Pipe
E10	Temperature	EMS	Condenser Wtr. Return Pipe
F1	kW Meter	EMS	MCC
F2	kW Meter	EMS	MCC
F3	Flowmeter	EMS	Hot Water Supply Pipe
F4	Temperature	EMS	Hot Water Supply Pipe
F5	Temperature	EMS	Hot Water Return Pipe
F6	kW Meter	EMS	Electric Panel
F7	Flowmeter	EMS	Condensate Pipe
F8	Pressure Gauge	Manual	Steam Pipe
F9	Flowmeter	EMS	Main Fuel Line

VII. ABBREVIATIONS

A/C - Air Conditioning
AFMS - Air Flow Measurement Station
AHU - Air Handling Unit
Amp - Ampere
BTU - British Thermal Unit
CAV - Constant Air Volume
CFH - Cubic Feet Per Hour
CT - Cooling Tower
CFM - Cubic Feet Per Minute
CHW - Chilled Water
CW - Condenser Water
CWV - Constant Water Volume
EMS - Energy Management System
ESC - Energy Star Computer
F - Fahrenheit
FC - Foot candle
GL - Green Lights
gpm - Gallons Per Minute
in - inch
kW - Kilo Watt
MCC - Motor Control Center
O.A. - Outside Air
psig - Pounds Per Square Inch (gauge)
R - Return
R.A. - Return Air
R.H. - Relative Humidity
RMS - Root Mean Square
S - Supply
S.A. - Supply Air
S.P. - Static Pressure
Temp. - Temperature
VAV - Variable Air Volume
V.P. - Velocity Pressure
VSD - Variable Speed Drive
VWV - Variable Water Volume
WC - Water Column